The effect of treatment duration on weaning weights in a cow-calf herd with a protracted severe outbreak of diarrhea in calves

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Abstract — The objective of this study was to describe a multiyear outbreak of calf diarrhea in an Alberta cow-calf herd and the impact of severe diarrhea on calf productivity. A retrospective analysis was performed through the use of detailed individual animal records and laboratory reports. The most significant laboratory finding was *Salmonella* Typhimurium isolated from the fecal samples of 2 ill members of the treatment crew and from 3 calves on postmortem examination. In 2002, at the peak of the outbreak, 90.3% (325/360) of the calves required treatment and 8.9% (32/360) of the calves died. In 2003, the severity of the problem had declined with only 20.9% (47/225) of the calves requiring treatment and 3.1% (7/225) of the calves dying. In both years, the weaning weights of treated calves were significantly reduced compared with those of nontreated calves. For calves weaned in 2002, after adjusting for the effect of calf sex, calves treated more than 6 times had 200-day adjusted weaning weights that were 15.2 kg (95% CI; 5.8 to 24.4 kg) lighter than of those calves treated only once or not at all ($P = 0.0015$, $n = 321$). For calves weaned in 2003, calves were 5.5 kg (95% CI; 0.23 to 10.8, $P = 0.04$, $n = 207$) lighter per treatment day with electrolytes, when calf sex and dam age were controlled for. Assuming that increased days of treatment or number of treatments is representative of disease severity, long-term calf performance is negatively affected by severe calfhood disease. The estimated lost revenue and treatment expenses, excluding the cost of labor, cow feed, and maintenance, was $22 800 in 2002 and $1589 in 2003.

Résumé — Effet de la durée du traitement sur le poids au sevrage dans un troupeau de vaches — veaux lors d'une forte flambée de diarrhée de longue durée chez les veaux. L'objectif de cette étude était de décrire une flambée de diarrhée s'étalant sur plusieurs années chez des veaux dans un troupeau vaches — veaux de l'Alberta et l'impact d'une grave diarrhée sur la productivité des veaux. Une analyse rétrospective a été réalisée en utilisant des dossiers individuels détaillés et des rapports de laboratoires. La trouvaille de laboratoire la plus significative était d'avoir isolé *Salmonella typhimurum* à partir d'échantillons fécaux de 2 individus de la cohorte de traitement et de 3 veaux à l'examen post mortem. En 2002, au pire de la flambée, 90,3 % (325/360) des veaux ont eu besoin d'être traités et 8,9 % (32/360) sont morts. En 2003, la sévérité de la maladie avait diminué et seulement 20,9 % (47/225) des veaux ont eu besoin d'au moins un traitement alors que 3,1 % (7/225) sont morts. Au cours des 2 années, les poids au sevrage des veaux traités étaient significativement plus faibles que ceux des veaux non traités. Parmi les veaux sevrés en 2002, les veaux traités plus de 6 fois pesaient 15,2 kg (95 % 1C; 5,8 à 24,4 kg) de moins que ceux traités une fois ou pas du tout ($P = 0{,}0015$, $n = 321$) après ajustement du poids au sevrage à 200 jours pour tenir compte de la différence entre les sexes. Les veaux sevrés en 2003 pesaient 5,5 kg (95 % 1C; 0,23 à 10,8, $P = 0{,}04$, $n = 207$) de moins par jour de traitement aux électrolytes, après ajustements pour le sexe du veau et l'âge de la mère. En supposant qu'une augmentation du nombre de jours de traitement ou que le nombre de traitements soit représentatif de la sévérité de la maladie, la performance à long terme est influencée négativement par une maladie grave survenant en bas âge. Le manque à gagner et les dépenses en soins, en excluant le coût de la main d'œuvre, de la nourriture des vaches et de l'entretien a été évalué à 22 800 $ en 2002 et 1589 $ en 2003.

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Introduction

Calf diarrhea is a major cause of economic loss to the North American cow-calf industry. A major survey of beef producers in the USA in 1997 found that 80% of calf morbidity from birth to 21 d is due to diarrhea (1). Economic losses associated with an outbreak can be substantial and far reaching. In addition to the costs associated with the additional labor, drug expenditures, and calf death, there is the potential economic impact associated with the poor long-term performance of affected calves. Adjusted weaning weights have been shown to decrease by up to 15.9 kg per affected calf due to calf morbidity (2).

Many of the organisms responsible for calf diarrhea are also important zoonotic pathogens. Infection with *Cryptosporidium* spp., *Giardia* spp., *Campylobacter* spp., *Salmonella* spp., and some types of *Escherichia coli* can cause disease in both humans and other species (3). The potential for zoonotic transmission is often overlooked by producers and veterinarians managing an outbreak of calf diarrhea.

In 2002, a cow-calf herd in central Alberta was in its 3rd y of a considerable calf diarrhea problem. Prior to 2000, the herd had experienced sporadic losses associated with calfhood diseases within the normal expected variation. The problem began early in the 2000 calving season and continued with ongoing calf diarrhea-related treatments and losses until after the end of the 2003 calving season. During the outbreak, 2 workers and 3 calves were diagnosed as being infected with *S.* Typhimurium.

The objectives of this study were to describe the *Salmonella*-associated outbreak of calf diarrhea in this cow-calf herd and the impact of calf disease on calf productivity.

Materials and methods

Study population and available records

Detailed individual records were available from calving season 2000 through to weaning 2003. Animal inventory, calving, treatment, disposal, birth weight, and weaning weight records had all been maintained. Herd size varied from 250 to 400 calving cows, depending on the year and the availability of feed. The herd owners had an on-farm feedlot for their weaned calves and raised their own herd replacement heifers.

The herd was intensively managed. A precalving vaccination against calf diarrhea (Scourguard 3KC; Animal Health Group, Pfizer Canada, London, Ontario), 2 mL/animal, IM, and a prebreeding vaccination against infectious bovine rhinotracheitis, bovine viral diarrhea, parainfluenza 3, and bovine respiratory syncytial viruses (Triangle 4; Ayerst Veterinary Laboratories, Guelph, Ontario), 2 mL/animal, IM or SC, were given annually to the breeding females. The same 4-way vaccine, as well as a vaccine against infection with clostridial species (Tasvax 8; Schering Plough Animal Health, Pointe-Claire, Quebec), 4 mL/animal, SC, was given to the calves at branding and repeated at weaning.

Calving management

The calving season extended from March 1st until May 31st. Two- and 3-year-old heifers were housed and calved separately from the cow herd. Animals assessed to be close to calving were separated and kept in a dry-lot maternity pen for closer observation. After calving, the dam and calf were moved into a 3 m × 3 m mothering pen. Calves were injected with selenium (Dystosel; Animal Health Group, Pfizer Canada), 1 mL/45 kg of bodyweight (BW), vitamin A and D (Bimeda MTC Animal Health, Cambridge, Ontario), 1 mL/calf, and long- acting penicillin (Derapen; Ayerst Veterinary Laboratories), 3 mL/calf. Male calves were castrated by using an elastrator ring.

All calves were given an identification marker and weighed. Once the calf was nursing regularly and the dam and calf had bonded, they were turned out into a separate cow or heifer nursing pasture. Fresh bedding was put in the mothering pens between housing different dams and calves, but the pen was cleaned out only if it was excessively wet or dirty.

At the start of the 2003 calving season, an anti-endotoxin vaccine (J-Vac; Merial, Baie d'Urfé, Quebec) was randomly allocated to approximately half of a group of 215 cows and heifers to investigate its potential to minimize the clinical signs of endotoxemia in affected calves. This vaccine is labeled for use in dairy cattle as an aid to prevent clinical mastitis caused by *E. coli* and to provide protection against the effects of endotoxemia associated with either *E. coli* or *S.* Typhimurium. The vaccine was administered according to the manufacturer's recommendations, 2 mL/animal, SC or IM. Of the animals enrolled, 106 were vaccinated and 109 were not vaccinated.

Treatment

Calves were treated on the farm. The herd owners' veterinary clinic was consulted on diagnosis and treatment strategy. Depending on their clinical signs and disease severity, the calves were treated with a variety of pharmaceuticals. Fecal consistency and rectal temperatures were recorded prior to initiation of treatment.

In 2002, the initial line of therapy was ampicillin (Novo-ampicillin; Novopharm, Toronto, Ontario), 10 mg/kg BW, PO, q24h; loperamide (Imodium; McNeil Consumer Healthcare, Guelph, Ontario), 4 mg, PO, q24h; and acetaminophen (Tylenol; McNeil Consumer Healthcare, Guelph, Ontario), 1000 to 1500 mg, PO, q24h. Ceftiofur (Excenel sterile powder; Pharmacia Animal Health, Orangeville, Ontario), 1.1 mg/kg BW, IM, q24h, was used as the 2nd line antimicrobial therapy. Length of treatment varied with individual animal cases. Antibiotics were switched and additional therapies, such as intestinal protectants, were added if no clinical improvement was noted or if the condition worsened. If diarrhea was prolonged, electrolytes (Calf-lyte; Vetoquinol, Lavaltrie, Quebec), 2 L, PO, q24h, were given. If dehydration was severe, lactated Ringer's solution, 2 L, IV, was also provided. All treatment data were recorded and entered onto a computer spreadsheet.

In 2003, calves were treated in a similar fashion, except that ceftiofur rather than ampicillin was used as the 1st line antibiotic.

Samples

The majority of laboratory samples were collected in 2002. Fecal samples were obtained from sick calves into a sterile 3-mL syringe, either directly from the calf's rectum or from a fresh bowel movement. The samples were frozen and stored in a chest freezer at -20ºC, until they were submitted to a commercial veterinary diagnostic laboratory. Routine and enrichment cultures for the isolation of *Salmonella* spp. and other pathogenic organisms were established, as were tests for parasites and systems for virus isolation. All *E. coli* isolates were forwarded for enterotoxigenic *E. coli* (ETEC) testing (Gallant Custom Laboratories, Cambridge, Ontario). In 2003, fecal samples were submitted for bacterial culture and antimicrobial sensitivity testing only. The 2003 samples were not frozen but shipped fresh to the laboratory on ice (4ºC).

Twenty-five of the 55 calves that died in 2002 and 10 of the 34 calves that died in 2003 were necropsied by the local veterinarian. Multiple fresh and fixed tissue samples were submitted to a private diagnostic laboratory for microbiologic and histopathologic examination

Data analysis

Farm records provided investigators with an opportunity to examine the effect of treatment on age-adjusted weaning weights. Treatment rates were calculated from the total number of calves treated at least once divided by the number of calves born alive. Prophylactic use of long-acting penicillin at birth was not considered in this calculation. The risk of death during the calving season was calculated from the number of calves born alive that died prior to the start of the next breeding season divided by the total number of calves born alive.

Statistical analyses were performed by using commercially available software programs (SPSS for Windows, version 11.0; Chicago, Illinois, USA; and SAS System for Windows, version 8; SAS Institute, Cary, North Carolina, USA). Adjusted 200-day weaning weights were used as a measure of calf productivity. The number of days that a calf was treated and the number of treatment episodes were summarized for each calf. A calf was considered treated, if it had been given a product from 1 or more of the following categories: anti-inflammatories, motility modifiers, intestinal protectants, antibiotics, and fluids (PO, IV, or both). The total number of days that a calf had been treated with a particular group of products or specific drug was also summarized. A new treatment episode was defined as one given when > 5 d had elapsed since the previous treatment.

Linear regression was used to test the association between the 200-day-adjusted weaning weights and total number of days treated with any product; total days treated with anti-inflammatories, total days treated with intestinal protectants or motility modifiers, total days treated with antibiotics, and total days treated with fluids. Additionally, the numbers of different anti-inflammatories, antibiotics, intestinal protectants or motility modifiers used was also investigated. The total number of treatments or number of treatment days were considered as an indicator of the severity of calf disease. Presumably, the more treatments given or the more days a calf was treated, the worse the health status of the calf.

In addition to calf age, the calf sex, cow age, and calf sire were examined as potential determinants of weaning weight. Cow age was divided into 4 categories: 2-year-olds (heifers), 3-year-olds (2nd calvers), 4- to 10-year-olds, and > 10 y old. The reference category that was used to compare the other categories with was the 4 to 10 y old cows.

Where $P < 0.05$ for more than 1 variable, a final model was developed by using backwards stepwise elimination. Only variables where $P < 0.05$ were considered significant and allowed to remain in the model. The correlations between the various treatment variables were examined by Pearson's and Spearman's correlation coefficients, as appropriate, to understand the potential for collinearity of models developed to predict weaning weight.

Logistic regression was used to examine the association between the use of the anti-endotoxemia vaccination and the risk of any calf being treated at least once, after adjusting for dam age. Logistic regression was also used to assess the relationship of the use of the anti-endotoxin vaccination and the risk of treatment in calves born to 2- and 3-year-old animals. Linear regression was used to examine the association between the use of an anti-endotoxemia vaccination and the 200-day-adjusted weaning weight, while adjusting for calf sex and dam age. Records of submissions from cattle for laboratory bacteriology examination for 2001 through 2003 were obtained from the regional diagnostic laboratory (Prairie Diagnostic Services, Saskatoon, Saskatchewan).

Results

In 2000, the initial year of the calf diarrhea outbreak, the risks of calf treatment and calf death were substantial, with treatments approaching 40% (150/376) and deaths nearing 16% (59/376). The problem continued in 2001, with 46.7% (178/383) of calves treated and a death loss of 12.8% (49/383). The outbreak finally peaked in the 2002 calving season, when 90.3% (325/360) of calves were treated.

Clinical signs in the affected calves included anorexia and depression that was accompanied by fever (> 40ºC), with or without diarrhea. In summary, the 2002 treatment records showed that 24.6% (80/325) of the treated calves had temperatures ≥ 40ºC and that 15.4% (50/325) had evidence of blood in their feces. The same trend continued in 2003; 25.5% (12/47) of the treated calves had pyrexia (≥ 40ºC). The median age of calves with fever was 9 d (range 2 to 74 d) in 2002, and 6 d (range 2 to 16 d) in 2003.

From the 25 calves that were necropsied in 2002, 7 (28.0%) were diagnosed with enteritis, 3 (12.0%) with septicemia, and 13 (52.0%) with conditions such as pneumonia and abomasal ulcers or conditions resulting from dystocia. No diagnosis was made for 2 of the calves. The following organisms were isolated from the tissues from the 25 necropsies that were submitted to the diagnostic laboratory; *E. coli* ($n = 3$), *rotavirus* ($n = 1$), and *Cryptosporidium* spp. ($n = 3$). *Salmonella* Typhimurium was confirmed in 3 calves. In 2003, 100% (10/10) of the necropsied calves were diagnosed with enteritis.

Eighteen fecal samples were collected in 2002. Thirteen of the 18 samples that were tested for the presence of enterotoxigenic *E. coli* were negative; *Coronavirus*

Table 1. Summary of calf birth weight and weaning weight (kg) for 2002 and 2003

Calf birth weight (kg)		Calf weaning weight (kg)	
Management group	Mean and standard deviation (s)	Management standard group	Mean and deviation (s)
2002 Heifers (n = 168)	41 (s, 5.8)	2002 Heifers (n = 162)	220 (s, 25.7)
2003 Heifers (n = 104)	41 (s, 5.4)	2003 Heifers (n = 97)	229 (s, 25.9)
2002 Bulls (n = 163)	43 (s, 5.5)	2002 Bulls (n = 159)	232 (s, 33.6)
2003 Bulls (n = 121)	44 (s, 5.7)	2003 Bulls (n = 110)	233 (s, 24.9)

Table 2. Death losses between birth and weaning for 2002 and 2003

Year	Herd size	Dead at birth	Born alive	Dead later	Total dead	Calf death rate[a]	Number to pasture	Missing in fall	Weaned
2002	383	23	360	32	55	8.9%	328	7	321
2003	251	27	225	7	34	3.1%	218	11	207

[a]Calf death rate calculated by the number of calves born alive that died prior to spring pasture turn out divided by the total number born alive

Table 3. Risk of treatment for calves for 2002 and 2003

Dams	Calves		
Year	Born alive	Treated	Attack rate
2002			
All breeding females	360	325	90.3
Heifers	70	62	88.6
2nd calvers	54	51	94.4
Mature cows	189	175	92.6
Unknown	47	37	78.7
2003			
All breeding females	225	47	20.9
Heifers	38	20	52.6
2nd calvers	41	10	24.4
Mature cows	146	17	11.6

spp. were identified in 2 samples. Twenty-two, cow-calf pair fecal samples were submitted in 2003 and cultured for *Salmonella* spp. No *Salmonella* spp. were identified in the fecal samples in either 2002 or 2003.

Heifer and bull calf birth weights for 2002 and 2003 were comparable. Between the years, mean birth weights were the same for heifers, but a 1-kg difference was seen for bull calves (Table 1). There was little difference in the adjusted 200-day weaning weights between the years for each sex (Table 1).

Calf mortality was 8.9% (32/360) and 3.1% (7/225) in 2002 and 2003, respectively, (Table 2). Treatment rates were substantially different between the years (Table 3); in 2002, 90.3% (325/360) of the calves were treated, whereas in 2003 only 20.9% (47/225) were treated.

For 2002, the cost of medications alone was $> \$7000.00$, while for 2003, the cost was closer to \$700. The average cost per treated calf was very similar; \$21.67 (325/\$7042.75) in 2002, and \$16.34 (47/\$767.01) in 2003. Treatment cost per calf on a herd basis, however, worked out to be \$19.50 (360/\$7041.01) in 2002, and \$3.40 (225/\$768.01) in 2003. The average number of treatment days and treatment episodes per treated calf were 4.1 and 2.0 in 2002 and 3.0 and 1.1 in 2003 (Table 4).

Calf sex was a significant predictor of adjusted weaning weight in both 2002 and 2003 In 2002, heifer calves were 24.4 kg (95% CI; 10.1 to 38.8 kg) lighter than bull calves ($P < 0.0001$). Similarly, in 2003, heifer calves were 29.3 kg (95% CI; 13.9 to 44.7 kg) lighter than bull calves ($P < 0.0001$).

Dam age was not significantly associated with calf age-adjusted weaning weights in 2002. In 2003, calves from 2- or 3-year-old animals were 11.9 kg (95% CI; 0.16 to 22.3 kg, $P = 0.02$) and 9.5 kg (95% CI; 0.6 to 18.4 kg, $P = 0.04$) lighter, respectively, than calves born to 4- to 10-year-old cows. Recorded calf sire was not a significant predictor of age-adjusted weaning weights for either year.

After correcting for calf sex, adjusted weaning weights of treated calves were 1.9 kg (95% CI; 0.95 to 2.8 kg) less for each day of treatment with an antibiotic ($P < 0.0001$, $n = 321$) (Table 5) and 3.9 kg (95% CI; 1.6 to 6.1 kg) less for each day of treatment with electrolytes ($P = 0.001$, $n = 321$) (Table 6). The potential for a threshold effect of duration of calf treatment on weaning weight was also considered by dividing the duration of calf treatment into quartiles for 2002 (Table 7). The resulting groups were calves treated either once or not at all, and calves treated 2 to 3 times, 4 to 5 times, and > 6 times. After adjusting for the effect of calf sex, calves treated > 6 times had 200-day adjusted weaning weights that were about 15.2 kg (95% CI; 5.8 to 24.4 kg) lighter than those of calves treated only once or not at all ($P = 0.0015$, $n = 321$).

In 2003, treatment was also associated with a decrease in 200-day adjusted weaning weights. At weaning, calves were 5.5 kg (95% CI 0.23 to 10.8, $P = 0.04$, $n = 207$) lighter per treatment day with electrolytes, when calf sex and dam age were controlled for (Table 8).

Table 4. Summary of the number of treatment days, treatment episodes, and drug administrations in total, and the maximum, minimum, and average number per calf

Treatment year	Total number	Maximum per calf	Minimum per calf	Average per calf
2002				
Calf treatment days[a]	1454	23	1	4.5
Drug administrations[b]	5337	122	1	16.4
Treatment episodes[c]	640	6	1	2.0
2003				
Calf treatment days	142	11	1	3.0
Drug administrations	492	43	1	10.5
Treatment episodes	52	2	1	1.1

[a]Calf treatment days — Total number of days any calf was treated summed for all calves
[b]Drug administrations — Total number of times any drug was administered over the calving season
[c]Treatment episodes — If greater than 5 d passed between treatments the next treatment was classified as a new treatment episode

Table 5. The association between 200-day adjusted weaning weight (kg) and total number of days antibiotics were used per calf in 2002 (*n* = 321)

Model	β	95% CI	*P*-value
Constant	238.5	232.6 to 244.4	< 0.0001
Sex (male)	11.7	5.3 to18.2	< 0.0001
Sex (female)	Reference level[a]		
Total number of days antibiotics were used	-1.9	-2.8 to -0.95	< 0.0001

β — regression coefficient
[a]Reference level — The regression co-efficient for male is generated by comparing male to female

Table 6. The association between 200-day adjusted weaning weights (kg) and total number of days electrolytes were used per calf in 2002 (*n* = 321)

Model	β	95% CI	*P*-value
Constant	233.3	228.5 to 238.1	< 0.0001
Sex (male)	10.8	4.3 to17.3	0.001
Sex (female)	Reference level[a]		
Total number of days electrolytes were used	-3.9	-6.1 to -1.63	0.001

β — regression coefficient
[a]Reference level — The regression co-efficient for male is generated by comparing male to female

Table 7. The association between 200-day adjusted weaning weight (kg) and total number of treatments used in 2002 (*n* = 321)

Model	β	95% CI	*P*-value
Constant	224.7	217.8 to 231.6	< 0.0001
Sex			
Male	10.7	4.26 to 17.1	0.0011
Female	Reference level[a]		
Number of treatments			
2 or 3 times	-2.3	-10.8 to 6.2	0.59
4 or 5 times	-0.95	-10.8 to 8.4	0.80
> 6 times	-15.2	-24.4 to -5.8	0.0015
0 or 1 time	Reference level		

β — regression coefficient
[a]Reference level — The regression co-efficient for male is generated by comparing male to female. For number of treatments the regression co-efficient for each category is generated by comparing each category to the 0 to 1 time treatment category

Table 8. The association between 200-day adjusted weaning weights (kg) and total number of days electrolytes were used per calf in 2003 (*n* = 207)

Model	β	95% CI	*P*-value
Constant	224.4	218.6 to 229.9	< 0.0001
Sex			
Male	12.3	5.6 to 19.0	0.0003
Female	Reference level[a]		
Dam age			
2 y	-11.9	-22.3 to -1.63	0.02
3 y	-9.5	-18.4 to -0.6	0.04
> 10 y	-1.9	-16.8 to -13.1	0.80
4 to10 y	Reference level		
Total number of days electrolytes were used	-5.5	-10.8 to -0.23	0.04

β — regression coefficient
[a]Reference level — The regression co-efficient for male is generated by comparing male to female. For dam age the regression co-efficient for each category is generated by comparing each category to the 4- to 10-year time treatment category

The anti-endotoxin vaccine did not affect adjusted 200-day weaning weights when adjusted for dam age, calf sex, and vaccine status. After controlling for dam age, there was also no association between the use of the anti-endotoxin vaccine prior to calving and subsequent calf treatment at the herd level. However, the use of the anti-endotoxin vaccine was associated with a significant reduction in the number of calves born to 1st calf heifers that required treatment. Calves that were born to 1st calf heifers that had received the anti-endotoxin vaccine were 7.0 (95% CI; 1.6 to 30.8, $P = 0.010$) times less likely to be treated than were calves born to 1st calf heifers that did not receive the anti-endotoxin vaccine.

Although no association was seen between the anti-endotoxin vaccination and subsequent calf treatment, there was a significant association between calf treatment and dam age when controlling for vaccination status. For the 2003 calf crop, calves born to 2-year-old heifers were 16.3 (95% CI; 6.3 to 34.8, $P < 0.0001$) times more likely to be treated than were calves born to 4-to 10-year-old cows. Similarly, calves born to 3-year-old dams were 3.6 (95% CI; 1.3 to 9.8, $P = 0.01$) times more likely to be treated than were calves born to dams 4- to 10-year-old dams. Additionally, calves born to 2-year-old heifers were 4.5 (95% CI; 1.6 to 12.4, $P = 0.004$) times more likely to be treated than were calves born to 3-year-old

Table 9. Distribution of cows by age category for 2002 and 2003

Cow age (years)	Number of animals (2002)	Proportion of herd (%) (2002)	Number of animals (2003)	Proportion of herd (%) (2003)
2	70	19.4	38	16.9
3	54	15.0	41	18.2
4 to 10	180	50.0	135	60
> 10	9	2.5	11	4.9
Missing	47	13.1	0	0
Totals	360	100	225	100

Table 10. Summary of submissions where *Salmonella* spp. were isolated as a percentage of all bovine diagnostic samples submitted for *Salmonella* spp. culture to regional laboratories in Saskatchewan, 2001 through 2003

	Proportion of positive isolates from bovine bacteriology submissions cultured for *Salmonella* spp.[a]		
	2001	2002	2003
Bovine submissions for *Salmonella* spp.	44/494 (8.9%)	63/748 (8.4%)	16/275 (5.8%)
Herd with submissions for *Salmonella* spp. culture	12/181 (6.6%)	24/220 (10.9%)	10/148 (6.8%)

[a]Record system did not permit differentiation of beef and dairy samples

dams. No significant difference was detected between calves born to cows > 10 y of age and cows 4 to 10 y of age.

Human cases

Two of the individuals who were directly responsible for treating the sick calves also experienced fever, diarrhea, nausea, and vomiting. In 2001, the ranch foreman reported severe fever and gastrointestinal signs for 5 d and lingering effects for months. The 2nd individual was affected in 2002 with similar signs that lasted for about 7 d. Medication was prescribed for both individuals by their family physician. Prior to treatment, fecal samples collected for culture from both individuals were confirmed to be positive for *S.* Typhimurium.

Reports of bacteriology submissions from regional laboratory

The record system from 2001 to 2003 did not have sufficient information to distinguish sample type or origin (beef or dairy herd). Only those submissions where culture for *Salmonella* spp. were attempted are reported here (Table 10). The maximum number of herds where a *Salmonella* sp. was isolated was 24 in 2002. This includes herds from both Saskatchewan and Alberta.

Discussion

The culture of *S.* Typhimurium, in 2001, from 1 of the persons responsible for treating the sick calves was not immediately connected to the illness in the calves. Unfortunately, the problem went undiagnosed in 2000 and 2001, and salmonellosis was not diagnosed in the calves until the 2002 calving season, when a 2nd worker was affected. Although there is no definitive evidence that the workers became infected from the calves, it is plausible because of the strong time and space association that existed between worker and sick calves and the presence of *S.* Typhimurium in both. The zoonotic involvement in this herd reemphasizes the importance of ensuring that precautions are taken when handling calves with diarrhea because of the potential risk for disease transmission.

The severity of this outbreak, despite good management practices, and the occurrence of human illness indicated that some laboratory work was needed to identify the causative agent. *Salmonella* Typhimurium was isolated from only a small number of postmortem samples, but the sensitivity of fecal culturing can be limited by intermittent shedding of the organism, the method of sample collection, the amount of sample submitted, and the bacteriological method used (4). Treatment of the animal, delays between collection and receipt of samples by the laboratory, and freezing of the samples prior to submission can also interfere with culture success (5). After *S.* Typhimurium was identified, additional fecal cultures would not have changed the control measures that had been implemented, so culturing fecal samples from the entire herd to identify carrier animals was not economically feasible for the herd owner

This study also provided an opportunity to measure the effect of calf disease on the long-term productivity of beef calves. In 2002, there was a significant difference in weaning weight between calves that were treated > 6 times and calves that were treated either once or not at all. This difference is consistent with other reports examining the cost of calf disease (2). Weaning weights were also significantly lighter in 2002 for each day of treatment with either an antibiotic or an electrolyte. In 2003, calves were lighter for every day of treatment with an electrolyte. Assuming that increased days of treatment or number of treatments is representative of disease severity, then long-term calf performance is affected by severe calfhood disease.

The economic cost of calf disease is not restricted to the initial cost of treatment or death of the calf. The additional cost of poor performance at weaning should be discussed when producers are being educated about the importance of calving management and biosecurity to limit the risk of disease in their herds. This herd experienced a substantial financial loss when taking into account the cost of treatments, calf deaths, and the total loss of kilograms per calf weaned. For example, in 2002, 72 animals that were treated $>$ 6 times were 15.2 kg lighter than were the animals not treated or treated only once. This translates into a loss of \$2955 (15.2 kg $\times$ 72 calves $\times$ \$2.70/kg), assuming that the average selling price, for a calf, was about \$2.70/kg (\$1.23 per pound) in 2002. Additionally, the expected postnatal death loss is assumed to be about 3%, the excess calf death loss for 2002 was 21 calves or 5.8% (21/360) (6). This translates into a \$12 814 (21 calves $\times$ 226 kg $\times$ \$2.70/kg) loss to the producer, based on the herds adjusted average weaning weight and the above price per kg. When the above figures are added to the cost of treatment for 2002, the producer lost a minimum of \$22 800 in expenses and potential revenue, without considering the cost of labor, cow feed, and maintenance. The total cost for calf treatments, excess loss, and reduced weaning weights were not estimated for 2000 and 2001; at the end of the outbreak in 2003, estimated losses were \$1589 for the year.

The incidence of disease in a herd depends on the balance between the amount of exposure to the agent and the level of resistance in the calf (7). Exposure can be decreased by isolating sick animals, moving the calving area, and practising good hygiene. In this herd, attempts were made to implement all of these practices to reduce calf exposure to disease.

Resistance to disease can also be increased by ensuring adequate high quality nutrition for the dam and calf and by ensuring that the calf ingests a sufficient amount of colostrum. Cow body condition for this herd was at or above accepted standards in all of the years in question. The large number of heifers in the herd may have affected the number of treatments provided, because calves born to heifers are at greater risk of failure of passive transfer than are calves born to cows (8). The number of heifers calving was lower in 2003 than in 2002, which is a possible explanation for some of the reduced risk for treatment seen in 2003 (Table 9).

Specific immunity to disease can be increased via vaccination. In this herd, a vaccination program against calf diarrhea was already in place and an anti-endotoxin vaccination program was added in 2003. The idea behind using the anti-endotoxin vaccine was to decrease the potential effect of endotoxemia in any calves infected with *Salmonella* spp. The use of the anti-endotoxin vaccine was associated with a significant reduction in the number of calves born to 1st calf heifers that required treatment. The vaccine effect for this group was examined because the risk of treatment and death loss was highest in the calves from these animals. When all herd animals were considered, the anti-endotoxin vaccination did not significantly affect either whether or not a calf was treated or the 200-day adjusted weaning weight, after controlling for dam age. However, *Salmonella* spp. were not isolated from the herd in the spring of 2003. Without documented challenge, the potential effectiveness of the vaccine could not be fully assessed.

Many control measures for undifferentiated calf diarrhea have been described (9,10). Specific control measures for *Salmonella* spp. in cattle herds are often difficult to implement and a single protocol certainly can not be applied to all situations. In a study of cattle herds in Virginia, significant risk factors that were identified included the number of mature cows in the herd, calves being born in buildings rather than outdoors, poultry manure being spread on bordering property, signs of rodents in cattle-housing or feed-storage areas, and contact of wild geese with cattle or feed (11). Calves on endemically infected farms may be exposed to *Salmonella* spp. via contaminated colostrum, contamination of teats and udders, farm personnel, equipment, or the environment (12). Carrier cows can shed up to 2.5×10^8 salmonella organisms per day in milk (13). Ingestion of contaminated milk from carrier cows and subsequent shedding by the calf will perpetuate the disease cycle. The role of contaminated colostrum in this herd was not investigated.

Maternity pen management can also increase the degree of exposure of a calf to infectious organisms (13). In this herd, the maternity pens were cleaned out only if they were excessively wet or dirty; instead, large amounts of fresh bedding were added between calving pairs. Complete removal of organic material and disinfection of maternity pens between calving pairs would have been useful in helping to break the disease cycle, but this was not feasible during peak calving periods and under extreme environmental conditions. Alternatively, the degree of calf exposure may also be reduced by starting the calving season later in the year and calving cows in a larger environment. Calving later in the season decreases the necessity of confinement for protection of the newborn from the severe cold and wind in western Canada. Reducing herd size to minimize environmental contamination and potential for infection, and implementing rodent and wildlife control measures are other potential ways of attempting to control this type of outbreak. Reduction of herd size may have potentially decreased the extent of environmental contamination in 2003, as the herd size in 2003 was smaller than in 2002 by 123 head. CVJ

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